MODULE 5

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5.1 CANALS

A canal is an artificial channel, generally trapezoidal in shape, constructed on the ground to carry water to the fields either from a river or tank or reservoir.

If the full supply level (FSL) of a canal is below the natural ground surface, an open cut or excavation is necessary to construct a canal. If the FSL of the canal is above the existing ground level, the canal is constructed by providing earthen banks on both sides. In the first case the channel is called a canal in cutting and in the second case it is called a canal in filling. Sometimes a canal can be of the intermediate type and the channel is called a canal in partial cutting and Partial filling.

5.1.1 CLASSIFICATION OF CANALS:

The irrigation canals can be classified in different ways based on the following considerations.

1. Classification based on the nature of source of supply:

a) Permanent canals

b) Inundation canals

- A permanent canal is one which draws water from a permanent source of supply. The canal in such cases is made as a regular graded canal (fixed slope). It is provided with permanent regulation and distribution works. A permanent canal may also be perennial canal or nonperennial canal depending on whether the source supplying water is a perennial one or a nonperennial.
- An inundation canal is one which draws water from a river when the water level in the river is high or the river is in floods. These canals are not provided with any regulatory works, but an open cut is made in the banks of the canal to divert water.

2. Classification based on the function of the canal:

a) Feeder canals

b) Carrier canals

c) Navigation canals

d) Power canals

- A feeder canal is constructed for the purpose of supplying water to two or more canals only but not directly irrigating the fields.
- A carrier canal carries water for irrigating the fields and also feeds other canals for their needs.

- A canal serving the purpose of in-land navigation is called a navigation canal.
- A power canal supplies water to a hydro electric power generation plant for generation of electrical power.

3. Classification based on the discharge and its relative importance in a given network of canals:

a) Main canal

b) Branch canal

c) Major distributory

d) Minor distributory

e) Water course or Field channel

- A main canal is the principal canal in a network of irrigation canals. It directly takes off from a river, reservoir or a feeder canal. It has large capacity and supplies water to branch canals and even to major distributaries.
- Branch canals take off from a main canal on either side at regular intervals. They carry a discharge of about 5 cumec and are not usually used to directly irrigate the fields.
- A major distributory takes off a branch canal or a main canal. It has a discharge capacity of 0.25 to 5 cumec. They are used for direct irrigation and also to feed minor distributaries.
- Minor distributaries are canals taking off from the branch canals and major distributaries. They carry a discharge less than 0.25 cumec. These canals supply water to field channels.
- A water course or field channel takes off from either a major or minor distributory or a branch canal also. These are constructed and maintained by the cultivators/farmers. The other canals are constructed and maintained by the government or the Command Area Development Authority.

4. Classification based on Canal alignment:

a) Ridge canal or watershed canal

b) Contour canal

c) Side slope canal

- A Ridge canal or watershed canal is one which runs along the ridge or watershed line. It can irrigate the fields on both sides. In case of ridge canals the necessity of cross drainage works does not arise as the canal is not intercepted by natural streams or drains.

- A contour canal is one which is aligned nearly parallel to the contours of the country/area. These canals can irrigate the lands on only one side. The ground level on one side is higher and hence bank on the higher side may not be necessary.
- A contour canal may be intercepted by natural streams/drains and hence cross drainage works may be essential.
- A Side slope canal is one which is aligned at right angles to the contour of the country/area. It is a canal running between a ridge and a valley. This canal is not intercepted by streams and hence no cross drainage works may be essential. This canal has steep bed slope since the ground has steep slope in a direction perpendicular to the contours of the country/area.

5. Classification based on the financial output:

a) Productive canals

b) Protective canals

- A productive canal is one which is fully developed and earns enough revenue for its running and maintenance and also recovers the cost of its initial investment. It is essential the cost of its initial investment is recovered within 16 years of construction.
- Protective canals are those constructed at times of famine to provide relief and employment to the people of the area. The revenue from such a canal may not be sufficient for its maintenance. The investment may also not be recovered within the stipulated time.

6. Classification based on the soil through which they are constructed:

a) Alluvial canals

b) Non-alluvial canals.

- Canals constructed in alluvial soils are known as alluvial canals. Alluvial soils are found in the Indo-Gangetic plains of North India. The alluvial soils can be easily scoured and deposited by water.
- Canals constructed through hard soils or disintegrated rocks are called non-alluvial canals. Such soils are usually found in Central and South India.

7. Classification based on lining being provided or not:

a) Unlined canals

b) Lined canals

- An unlined canal is one which the bed and banks of the canal are made up of natural soil through which it is constructed. A protective lining of impervious material is not provided. The velocity of flow is kept low such that bed and banks are not scoured.
- A lined canal is one which is provide with a lining of impervious material on its banks and beds, to prevent the seepage of water and also scouring of banks and bed. Higher velocity for water can be permitted in lined canals and hence cross sectional area can be reduced.

5.1.2 CANAL ALIGNMENT

In aligning an irrigation canal, the following points must be considered.

1. An irrigation canal should be aligned in such a way that maximum area is irrigated with least length of canal.
2. Cross drainage works should be avoided as far as possible, such that the cost is reduced.
3. The off taking point of the canal from the source should be on a ridge, such that the canal must run as a ridge canal and irrigate lands on both sides.
4. Sharp curves in canals must be avoided.
5. In hilly areas, when it is not possible to construct ridge canals, the canal must be made to run as a contour canal.
6. The canal should be aligned such that the idle length of the canal is minimum.
7. The alignment should be such that heavy cutting or heavy filling are avoided. If possible balanced depth of cutting and filling is achieved.
8. It should not be aligned in rocky and cracked strata.
9. The alignment should avoid villages, roads, places of worship and other obligatory points.

5.1.3 DRAW BACKS IN KENNEDY'S THEORY:

1. Kutters equation is used for determining the mean velocity of flow and hence the limitations of kutter's equation are incorporated in Kennedy's theory.
2. The significance of B/D ratio is not considered in the theory
3. No equation for the bed slope has been given which may lead to varied designs of the channel with slight variation in the bed slope.

4. Silt charge and silt grade are not considered. The complex phenomenon of silt transportation is incorporated in a single factor are called critical velocity ratio.
5. The value of m is decided arbitrarily since there is no method given for determining its value.
6. This theory is aimed to design only an average regime channel.
7. The design of channel by the method based on this theory involves trial and error which is quite cumbersome.

5.1.4 DRAW BACKS IN LACEY'S THEORY:

1. The theory does not give a clear description of physical aspects of the problem.
2. It does not define what actually governs the characteristics of an alluvial channel.
3. The derivation of various formulae depends upon a single factor f and dependence on single factor f is not adequate.
4. There are different phases of flow on bed and sides and hence different values of silt factor for bed and side should have been used.
5. Lacey's equations do not include a concentration of silt as variable.
6. Lacey did not take into account the silt left in channel by water that is lost in absorption which is as much as 12 to 15% of the total discharge of channel.
7. The effect of silt accumulation was also ignored. The silt size does actually go on decreasing by the process attrition among the rolling silt particles dragged along the bed.
8. Lacey did not properly define the silt grade and silt charge.
9. Lacey introduced semi ellipse as ideal shape of a regime channel which is not correct.

5.2 RESERVOIR

5.2.1 INVESTIGATIONS FOR RESERVOIR:

Following are the investigations that are usually conducted for reservoir planning.

1. Engineering Investigations / Surveys
2. Geological Investigations
3. Hydrologic Investigations

Engineering investigations / surveys:

- Generally Engineering Surveys are conducted for the dam, the reservoir and their associated works. During this investigation topographic survey of the area is carried out and the contour plan is prepared. The horizontal control is usually provided by triangulation survey and vertical control by precise leveling.
- At the dam site, very accurate triangulation survey is conducted and a contour plan to a scale of 1:250 or 1:500 is generally prepared with contour intervals in the range of 1 to 2 m. Such a survey should cover an area at hart upto 200 m upstream 400 m downstream and for adequate width beyond the two abutments.
- For the reservoir, the contour plan is generally prepared to a scale of 1:15,000 with contour intervals between 2 to 3 m. The area elevation and storage elevation curves are prepared for different elevations upto an elevation of 3 to 5 m higher than the anticipated maximum water level.

Geological investigations:

Following are the reasons for carrying out the Geological investigations at a reservoir site:

- Suitability of foundation for the dam.
- Water tightness of the reservoir basis.
- Location of quarry sites for the construction.

Hydrological investigations:

Following purposes demand the hydrological investigations:

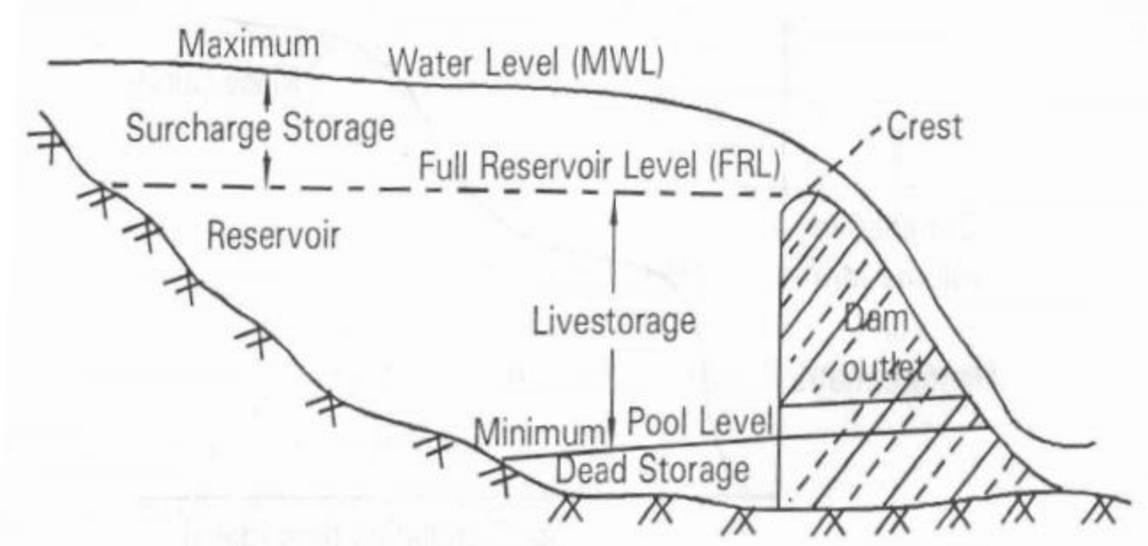
- To study the runoff pattern and to estimate yield.
- To determine the maximum discharge at the site.

5.2.2 SELECTION OF SITE FOR A RESERVOIR

A good site for a reservoir should have the following characteristics:

- Large storage capacity: The topography of the proposed site should be such that the reservoir has a large capacity for storing the water.
- Suitable site for the dam: A suitable site for the proposed dam should be available on the downstream side of the reservoir, with very good foundation; narrow opening in the valley to provide minimum length of the dam and also the cost of construction should be minimum.
- Water tightness of the reservoir: Geology at the proposed reservoir site should be such that the entire reservoir basin is water tight. They should have Granite, Gneiss, Schists, Slates, or Shales etc.
- Good hydrological conditions: The hydrological conditions of the river at the reservoir should give high yield. Evaporation, transpiration, and percolation losses should be minimum.
- Deep reservoir: The proposed site should be such that a deep reservoir is formed after the dam construction. The reason being evaporation losses would be minimum; in addition to low cost of land acquisition and less weed growth.
- Small Submerged area: At the proposed site, the submerged area should be minimum and should not affect the ecology of the area. Important places, monuments, roads, railway lines should not sub merge.
- Minimum silt inflow: The life of reservoir is defined by the quantity of silt inflow, which means that, if the silt inflow is large, the life would be less. Hence, it is necessary to select the reservoir site at such a place, where the silt inflow is minimum.
- No objectionable minerals: The proposed site should be free from soluble and objectionable salts, which may pollute the reservoir.
- Minimum acquisition and construction cost: The overall cost of the project should be minimum in terms of dam construction, land acquisition for reservoir, buildings, roads, railways etc.

5.2.3 STORAGE ZONES OF A RESERVOIR:



1. Live Storage or useful storage: Is that amount of water available or stored between the minimum pool level (LWL) and the full reservoir level (FRL). Minimum pool level or low water level is fixed after considering the minimum working head required for the efficient working of turbines.
2. Surcharge Storage: Is the volume of water stored above the full reservoir level (FRL) up to the maximum water level (MWL) In case of a multipurpose reservoir, useful storage or live storage is divided into A. Conservation storage B. Flood control storage
3. Dead storage: Is the volume of water held below the minimum pool level. This storage is not useful and hence cannot be used for any purpose under ordinary operating conditions.
4. Bank storage: Water stored in the banks of a river is known as bank storage. In most of the reservoirs the bank storage is small since the banks are generally impervious.
5. Valley storage: Is the volume of water held by the natural river channel in its valley upto the top of its banks before the construction of the reservoir. The valley storage depends upon the cross section of the river, the length of the river and its water level.

5.2.4 DETERMINATION OF STORAGE CAPACITY USING MASS CURVES

Mass Curve is a graphical representation of cumulative volume of water in the reservoir Vs cumulative time. It will be a continuously raising curve.

Fixing Capacity of a reservoir Capacity of a reservoir depends on the inflow and demand. It is a fact that if the available inflow is more than the demand, there is no necessity of any storage. On the other hand, if the inflow is less and demand is high a large reservoir capacity is required. Capacity for a reservoir can be determined by the following methods

(i) Mass curve or graphical method

(ii) Analytical method

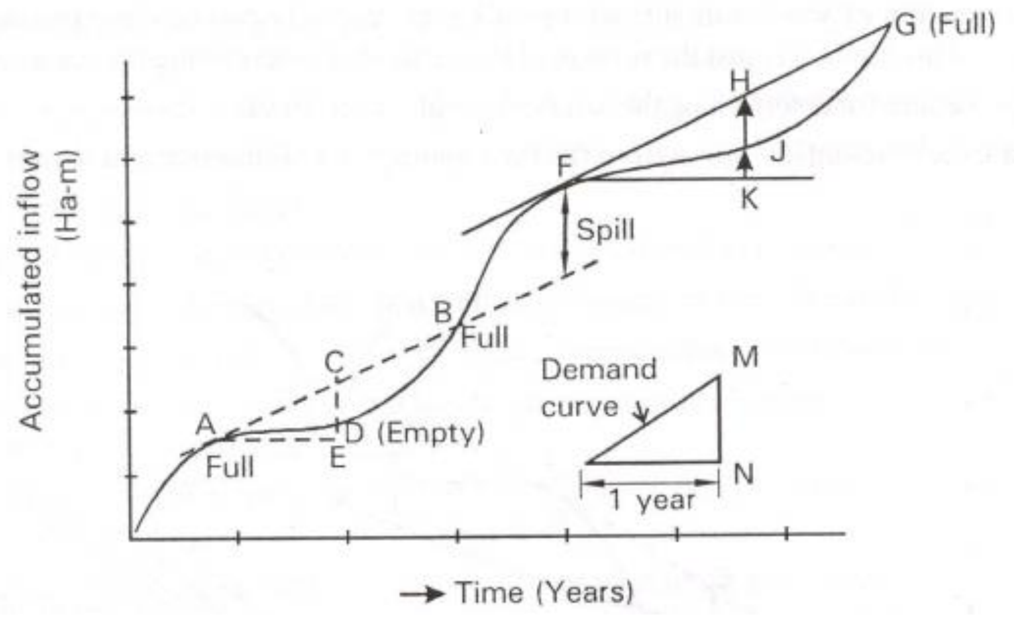
(iii) Flow duration curve method

Mass curve method or Graphical method

Storage required for uniform demand: In the case of uniform demand, the mass curve will be a straight line.

The procedure adopted will be as follows:

1. Prepare the mass inflow curve for the flow hydrograph of the site for a number of consecutive years including the most critical years (or the driest years) when the discharge is low, Fig shows the mass inflow curve.
2. Prepare the mass demand curve corresponding to the given rate of demand. If the rate of demand is constant, the mass demand curve is a straight line as shown in fig. 1.3. The scale selected for plotting of the mass inflow and mass demand curve should be the same.



3. Draw the lines AB, FG etc. such that they are parallel to the mass demand curve, and they are tangential to the peak points or crests at A, F etc. of the mass inflow curve points A, F, etc. indicate the beginning of dry periods marked by the depressions.
4. Determine the vertical intercepts CD, HJ etc. between the tangential lines and the mass inflow curve. These intercepts indicate the volumes by which the inflow volumes fall short of demand, which can be explained as follows:

- Assuming that the reservoir is full at point A, the inflow volume during the period AE is equal to ordinate DE and the demand is equal to ordinate CE. Thus the storage required is equal to the volume intercepted by the intercept CD.

5. Determine the largest of the vertical intercept determined in step (4). The largest vertical intercept represents the storage capacity required. Following import points have to be noted:

- The capacity obtained in the net storage capacity which must be available to meet the demand. The gross capacity of the reservoir will be more than the net storage capacity. It is obtained by adding the evaporation and seepage losses to the net storage capacity.
- The tangential lines AB, FG etc. when extended forward must interest the inflow curve. This is necessary for the reservoir to get filled again. If these lines do not intersect the mass curve, the reservoir would not fill again. Many times very large reservoirs may not get refilled every year.
- The vertical distance such as FL between the successive tangents represents the volume of water flowing over the spillway.

5.3 IMPORTANT QUESTIONS

- What are the considerations made during alignment of canals?
- Write a note on canal classification?
- Write a short note on:
  (a) Critical velocity ratio (b) Regime Channel
- Design and sketch a trapezoidal canal by Kennedy's theory for a discharge of 5 cumec. The channel is to be laid on a slope of 0.2m per kilometer. Assume: N = 0.025 and m=1.
- Determine the dimensions of the irrigation canal for the following data B/D ratio = 3.7, N = 0.0225, m = 1.0 and S = 1/4000 side slopes of the channel are 0.5H: 1V. Also determine the discharge which will be flowing in the channel.
- Design a irrigation channel in alluvial soil according to Lacey's silt theory for the following data:
  Full supply discharge = 10 cumec
  Lacey's silt factor = 0.9
  Side slopes of channel = 0.5H: 1V
- The slope of the channel in alluvium is 1/4000. Lacey's silt factor is 0.9 and side slopes are 0.5H: 1V. Find the channel section and maximum discharge which can be allowed to flow in it.

- Explain with neat sketch storage zones of reservoir.
- Explain the different investigations conducted before selecting a reservoir site.
- Explain the determination of storage capacity of reservoir by mass curves.

5.4 OUTCOMES

- Understand the concept of designing a canal and reservoir

5.5 FURTHER READING

- https://nptel.ac.in/courses/105105110
- https://nptel.ac.in/courses/105105110/29